DEVELOPMENT OF INSTRUMENTATION FOR HYPERSONIC INFLATABLE AERODYNAMIC DECELERATOR CHARACTERIZATION

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ABSTRACT

To realize the National Aeronautics and Space Administration's (NASA) goal of sending humans to Mars, development of technologies to facilitate the landing of heavy payloads are being explored. Current entry, descent, and landing technologies are not practical for heavy payloads due to mass and volume constraints dictated by limitations imposed by launch vehicle fairings. Therefore, technologies are now being explored to provide a mass- and volume-efficient solution for heavy payload capabilities, including Inflatable Aerodynamic Decelerators (IADs) [1]. Consideration of IADs for space applications has prompted the development of instrumentation systems for integration with flexible structures to characterize system response to flight-like environment testing. This development opportunity faces many challenges specific to inflatable structures in extreme environments, including but not limited to physical flexibility, packaging, temperature, structural integration and data acquisition [2].

In the fall of 2011, three large scale Hypersonic Inflatable Aerodynamic Decelerators (HIAD) will be tested in the National Full-Scale Aerodynamics Complex's (NFAC) 40' by 80' wind tunnel at NASA Ames Research Center. The test series will characterize the performance of a 3.0 m, 6.0 m, and 8.3 m HIAD at various angles of attack and levels of inflation during flight like loading. To analyze the performance of these test articles as they undergo aerodynamic loading, an instrumentation system has been developed. This system will utilize new experimental sensing concepts, developed by the large scale HIAD instrumentation team, in addition to traditional wind tunnel sensing techniques in an effort to improve test article characterization. The instrumentation system will target HIAD pressure distribution, flexible aeroshell static and dynamic deformation, rigid hardware stress, torus inflation pressure, and flexible aeroshell structural strap loading. Pressure measurements on the rigid HIAD hardware and in the inflatable tori will be conducted using traditional systems, while MEMS pressure sensors will be integrated into the flexible aeroshell in a new experimental concept. In addition, an approach to monitor static and dynamic deformation in the HIAD's flexible aeroshell will be characterized using string potentiometers to provide a reference distance from the supporting test structure. Stress seen by the rigid hardware will be characterized by traditional strain gages.

During this test series, we will also explore many developmental embedded sensing concepts for space flight test applications. Bend sensors will be incorporated into the HIAD Thermal Protection System (TPS) between structural tori presenting an indication of the deformation seen during aerodynamic loading. Flight-like configurations of the MEMS pressure sensors will also be tested accounting for on orbit and re-entry environmental constraints. Finally, MEMS accelerometers will be co-located with the string potentiometers as a proof of concept to measure deflection during flight. All developmental embedded sensing concepts will utilize flexible printed circuit board technology in order to meet the stringent launch packaging requirements of the HIAD aeroshell minimizing the risk of initiating punctures in the flexible materials. Additionally, a subset of the embedded sensing concepts will employ wireless data transfer reducing the wiring bundle mass and complexity.

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[2] Brandon, E.J. et al., Structural Health Management Technologies for Inflatable / Deployable Structures: Integrated Sensing and Self-Healing, Acta Astronautica (2010), doi:10.1016/j.actaastro.2010.08.016